

existing meters and to develop standard measurement assumptions and techniques. Once this is done, additional measurements under actual field conditions will be needed to ensure the development of analytical compliance models which are not more restrictive of broadcasters than necessary to protect human health under real world conditions. Further, given the difficulties inherent in measuring contact currents, we urge that broadcasters be permitted to comply with this standard by assuring that tower workers wear protective clothing and gloves; similarly, pending the development of appropriate compliance models, they should be permitted to assume compliance as to metallic objects not in direct contact with an antenna based on their meeting the relevant requirements for maximum permissible exposure.

Broadcaster and equipment manufacturers will cooperate to conform to the new rules, after a suitable transition period. But the FCC must be vigilant to ensure that inconsistent state and local regulation does not undermine important federal policies. Accordingly, the Broadcast Joint Commenters recommend exploring, in a *Further*

Notice of Proposed Rulemaking, possible preemption of state and local regulations that undermine Commission programs implementing the Communications Act.

Respectfully submitted,

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January 25, 1994

ENGINEERING STATEMENT

OF

ALAN W. PARNAU

JANUARY 24, 1994

**ENGINEERING STATEMENT OF ALAN W. PARNAU
IN CONNECTION WITH THE COMMENTS OF
CBS INC.
ON ET DOCKET 93-62
NON-IONIZING RADIATION STANDARDS**

QUALIFICATIONS

My name is Alan W. Parnau. I am the Director, Transmission Systems for the CBS Radio Division, a Division of CBS Inc., with offices in New York, New York. I hold a Bachelor of Science Degree in Electrical Engineering from Newark College of Engineering (now New Jersey Institute of Technology), class of 1974. I have held a Professional Engineering License from the State of New Jersey since 1986. I have been regularly employed in the field of broadcast engineering for 20 years, including approximately five years with CBS. I have been making and interpreting field measurements during my entire career and have been making and interpreting RF exposure measurements for the last five years.

INTRODUCTION

When the FCC proposed adopting the new ANSI/IEEE C95.1-1992 RF exposure standard as its guideline for exposure of humans to RF radiation, CBS began to consider how compliance with this new, and generally more restrictive, standard could be demonstrated. At present, under the FCC's compliance manual (OST 65), broadcasters often refer to tables, charts, and equations to determine

compliance with the current (1982) standard. If compliance cannot be determined by these techniques, actual measurements must be performed.

I have studied the revised draft of "Proposed Revision of OST Bulletin No. 65," prepared by Jules Cohen and dated October 12, 1993. The study is the result of Mr. Cohen's efforts, as commissioned by the National Association of Broadcasters, to develop non-measurement based techniques to demonstrate compliance with the new ANSI/IEEE standard. Of particular concern to me were the charts and graphs that he developed to demonstrate compliance with the new ANSI/IEEE standard respecting body currents. These charts and graphs attempt to establish guideline RF field levels that would provide assurance that an RF induced body current would not exceed the new standard. At frequencies of interest to TV and FM broadcasters, Mr. Cohen's work indicated that compliance with the induced current standards could be assured when the electric ("E") fields were within a range of approximately 16 to 42 percent of the ANSI/IEEE maximum permissible exposure ("MPE") electric field level.

Mr. Cohen's work is exemplary of the type of study that needs to be done to develop non-measurement based techniques for compliance with the induced current standard. However, based on conversations with Mr. Cohen, I understand that his estimates were derived from data gathered by others under disparate, and sometimes

unrealistic, conditions. Because Mr. Cohen's mandate was, in the first instance, to develop a worst-case analysis, the underlying data he used were derived under conditions where people, standing barefoot on well-grounded copper plates, were exposed to vertically-polarized plane waves. I do not believe that these measurements approximate real world conditions. As the Cohen study itself recognizes, FM and TV broadcast transmissions are horizontally - and circularly-polarized, not vertically-polarized. Moreover, most people who are exposed to RF radiation are not barefoot, but wear shoes and socks (or at least some kind of footwear), and the shoes are often rubber-soled. Additionally, under most conditions, it would be unusual for a person exposed to broadcast emissions to be standing on a well-grounded copper plate. More likely, such a person would be standing on dirt, grass, concrete, gravel, tar, or some other less conducting surface. Accordingly, one would expect that a person exposed to broadcast signals in the real world would absorb significantly less energy and, consequently, experience far less induced current than predicted by these studies.

I believe that the Cohen study is precisely the type of analysis that should be done to establish guidelines to demonstrate compliance. However, since Mr. Cohen's results were deliberately based on data gathered under unrealistic, worst case conditions, my colleagues and I believed that the proposed guidelines were overly-conservative.

Accordingly, CBS decided to undertake a more realistic measurement program to try to determine the relationship, under actual field conditions, between the E field and the resultant current induced by exposure to the field.

METHODOLOGY

In order to develop additional data to establish a relationship between induced currents and the maximum permissible exposure (MPE) limits, measurements were taken by me at the following eight AM, FM and TV broadcast sites: High Island, New York; Novato, California; Mt. Beacon, San Francisco; Mt. San Bruno, San Francisco; Mt. Wilson, Los Angeles; Torrance, California; Irwindale, California; and Flint Peak, California. The broadcast facilities at each of these locations are listed in Appendix A, Table 1. Full details for each site are contained in Appendix B, including site maps and lists of various emitters at each location.

The measurements taken at each site included both RF field and induced body current readings for each of a number of locations. The RF field measurements were made using a Holaday HI-3002 Isotropic Broadband RF Field Strength Meter (the "RF meter"). Induced body current measurements at the first sites surveyed were made with a prototype Narda induced body current meter. (CBS had ordered a production unit of the meter in early November, but was informed that the meters were still in the process

of being manufactured and had not yet been shipped. Because of the necessity of making the measurements in a time frame that would allow their inclusion in initial comments to be filed in this proceeding, CBS borrowed a prototype meter from Narda.) CBS received the production version of the induced current meter -- Model 8850 -- from Narda in mid-December. All measurements made subsequent to the delivery of the production model were made with that meter. For each of the broadcast sites measured, Table 1 of Appendix A also indicates the date on which I took the measurements and whether the prototype or production model was used.

At each of the eight broadcast transmission sites listed in Appendix A, Table 1, I initially walked around the site with the RF meter to determine locations where there were appreciable electric fields. At these locations -- between one and four per transmitter site -- I measured the field exposure in half-foot intervals from six inches above ground to six feet above ground. At each spot, the resulting 12 readings were then averaged to determine the whole body averaged exposure in volts per meter (V/m). Appendix B contains readings and averages for each location where measurements were taken.

At each location, once the RF measurements were completed, the body current was then measured with either the prototype or production model induced current meter in accordance with the manufacturer's instructions. Eight

body current measurements were made at each location, consisting of the various combinations of bare feet, shoes and socks on, one foot on the meter, two feet on the meter, hands at the side, and hands over the head. The results of these measurements for each location are also contained in Appendix B specific to each measurement spot. Additionally, the readings have been summarized and included in Appendix A, Tables 2 through 5.

METER AND MEASUREMENT DISCREPANCIES

While carrying out this measurement program, I observed several peculiarities of the induced body current meter. The meter is used by placing it on the ground, then adjusting a zero control. A person then stands on the meter, and reads the resulting induced current. I had to bend over and adjust the zero control, then stand upright several times to get the meter to read zero while I was standing in an upright position.

At one location at an FM transmission site, I noted that when I bent over and adjusted the zero control to zero, then stood upright, before getting on the meter, the meter reading changed by 10 milliamps. Since the induced current reading at this site was between 8 mA and 28 mA, I believe that the above-noted variation is significant. I observed similar significant variations at the other FM sites. Based on these observations, it appears that the

presence of the body and the position of the body disturb the field to a significant degree.

Another problem that I encountered was that the readings on one side of both the prototype and production models of the induced current meter appeared to be substantially attenuated. At each of the FM/TV sites at which I used the prototype meter, after obtaining a current reading with both feet on the meter, I found that when I lifted my right foot, the reading changed very little, but when I lifted my left foot, the readings went down substantially, sometimes almost to zero. I tried this again by standing backwards on the meter, and again found that the right side appeared to have little response. Two other people tried this experiment, to confirm that the problem was not peculiar to me. I experienced similar discrepancies at both AM and FM/TV sites with the production model; however, at one location within the Mt. Wilson site, the right side of the meter was responsive, but not the left side.

When performing the measurements at Mt. Wilson and Flint Peak with the production model, I noted that, once the meter was zeroed, the readings would change by 10-20 milliamps simply by leaning to the left or right a few inches. (Again, I note that the induced current readings at these sites vary from 20 mA to 30 mA.) Also, when performing the measurements at Flint Peak and two locations at Mt. Wilson, I found I could not get the induced current

meter to go to zero. However, at Flint Peak at another location about one foot away, I was able to zero the meter. At Mt. Wilson, at one point, moving the meter about 10 feet allowed it to be zeroed, but at another location, I could find no spot where I could zero the meter. The prototype model behaved in a similar fashion when used at Mt. Beacon and Mt. San Bruno, however, exact data was not recorded.

In addition, at one of the Mt. Beacon locations, I found that the electric field readings were well within the ANSI/IEEE MPE levels, but that the induced current readings were extremely high for no apparent reason.

THE DATA

Appendix B contains the site specific data for each measurement location. Appendix B is organized as follows: Each of the eight sites is a separate part of Appendix B. For each site, the first page (Figure 1-1, 2-1, 3-1, etc.) is a plat or map of the site, with markings indicating the measurement locations chosen within that site. The next page (Figure 1-2, 2-2, 3-2, etc.) is a list of the principal emitters located at that site.

Thereafter, within each site, the data is set forth by measurement locations, denominated A through D (between one and four measurement locations were chosen at each site, so the sites have differing amounts of measurement data). For each measurement location, the first chart (Figure 1A-1, 1B-1, etc.) contains the electric field measurements and

the whole body averaging calculation used to derive the volts/meter measurement at that spot. The second chart (Figure 1A-2, 1B-2, etc.) shows the induced current measurements, in milliamps. Measurements were taken with bare feet and with shoes and socks, and with my hands at my side and with my hands over my head, with one foot on the meter and then two feet, for a total of eight induced current measurements per measurement location.

The third chart within each measurement location (Figure 1A-3, 1B-3, etc.) is not measured data but derived data. It consists of the various current measurements contained in the second chart (in milliamps) *divided by* the measured electric field (in volts/meter). The resultant eight figures (again, representing the combinations of bare feet/shoes, hands over head/at side, and one foot/two feet) are in milliamps/volt/meter. These data represent the induced current at that measurement location *per* a given electric field. In other words, the third chart for each measurement location relates the induced current reading to the electric field strength readings.

ANALYSIS

The difficulty that I experienced in making measurements leads me to believe that it would be difficult, if not impossible, to repeat measurements of induced body currents. Consequently, I have concluded that

induced current measurements are not reliable, especially at VHF frequencies.

In my opinion, the variations in measurement and "zeroing" described above were caused by standing waves at the locations where the readings were taken. I believe that areas surrounding broadcast antennae contain many standing waves that are caused by the reflection of the transmitted wave off the surface of an object or the ground. When the directly transmitted and reflected waves add, an interference pattern is set up, causing peaks and nulls in the electric field, similar to the standing waves in a mismatched transmission line. I believe that these standing waves caused the variation in aforementioned induced current measurements. However, due to the randomness of the reflections at an antenna site, the standing wave pattern is highly unpredictable and, therefore, not amenable to analysis. Thus, by leaning or by moving only a short distance, the measurer's body may be moving from a peak to a null (or at least from a higher field level to a lower one) in the standing wave pattern. Additionally, the changing position of the body in the field changes the field itself. Either effect would result in a significant change in the induced current reading.

The foregoing effects were observed principally at the FM and TV sites, and to a much lesser degree at the AM sites. I believe that this might be due to the much longer wavelengths at AM frequencies. Since buildings and fence

posts are a much smaller fraction of a wavelength at AM frequencies, they are much less efficient re-radiators and cause much less of an interference pattern.

In determining compliance by measuring the electric and magnetic ("H") fields, it is our general practice to hold a meter and walk around the antenna site to determine if any point at the site is in excess of the MPE levels. Consequently, the variations in E fields discussed above have no practical effect on complying with the ANSI/IEEE MPE standards. However, I believe that field variations can have a significant effect on complying with the ANSI/IEEE induced current standard.

Because existing induced current meters must be set on the ground and are essentially immobile, it will be impossible to monitor a site (in a manner similar to that discussed above with regard to MPE compliance) in order to determine whether any location at the site is in excess of the induced current standard. Since rapidly changing spacial fields will result in different induced currents from one point to another, unless exhaustive measurements are taken over the entire site, it will be impossible to know whether a site is in compliance with the induced current standard. Such measurements are now impractical, if not virtually impossible. Thus, if the Commission or any other entity attempted to determine whether a site was in compliance, unless readings were repeated at the identical locations and with the person taking the readings

aligned with the antenna (and all of the reflecting "antennae") in exactly the same manner as was originally done -- a highly unlikely scenario -- one would expect the two sets of measurements to be different. Assuming that the initial set of readings "demonstrated" compliance, the second set of readings might well "demonstrate" non-compliance, particularly where the initial set of readings were close to the ANSI/IEEE limits. Therefore, I believe that, using the current state-of-the-art meters and measurement techniques, measurements of induced currents are not repeatable and consequently not reliable.

Moreover, except to the extent that the presence of a person in the field may affect the field itself, measurements of electric and magnetic fields are independent of the height and girth of the person taking the readings. However, induced currents are determined in large part by the height of the person in question. Therefore, unless all measurements are taken by the same person or one of remarkably similar stature, the readings might not be repeatable.

The dependence of the amount of current induced in the body on the height of the individual suggests another regulatory problem. While broadcasters can be assured of compliance with the ANSI/IEEE MPE standard so long as measurements indicate that the electric and magnetic fields are within MPE tolerances, the same cannot be said with regard to compliance with the ANSI/IEEE induced current

standard. Since induced currents are a function of the size of the person measuring the current (or the characteristics of any human equivalent model), without further guidance a licensee could never be assured, based on measurements demonstrating compliance taken by one person, that the standard would be met for other persons.

Moreover, there are other, less explainable anomalies. The most obvious is contained at the third measurement location (in front of the KCBS phasor) for the second transmitter site, the Novato, California, site. Here, for reasons that I cannot explain, induced current readings were about twice the levels recorded at two other locations at the site, despite the fact that the electric field measurements at the first location were far less than the field at the other two locations. A similar occurrence was observed at one of the Mt. Beacon measurement locations. I consider these readings to be inaccurate, and so have not included it in my analysis.¹

RESULTS

Appendix A contains the summarized results of this investigation. Table 1 in Appendix A is the list of the transmitter sites, the measurement locations within those sites, the dates of measurements, and the type of meter (prototype or production) used.

¹ These two sets of anomalous data are not depicted in the figures in Appendix A.

Appendix A, Figures 1 through 4 present the results graphically. These graphs depict induced current divided by exposure at each site in the four different feet and hand configurations. Figure 1 covers AM frequencies with two feet on the meter; Figure 2 is also AM frequencies, this time with one foot on the meter. Figure 3 lists the FM-TV data (*i.e.*, VHF) for two feet on the meter; Figure 4 is the same for one foot on the meter.

In each case, the ANSI/IEEE standard for induced current divided by exposure is also included. The ANSI/IEEE standard is derived by dividing the maximum permitted induced current (in mA) by the maximum permitted E field (in volts/meter). This calculation was performed at AM, and then at VHF frequencies, for both the controlled and the uncontrolled levels.² Those same results are also contained in Appendix A, Tables 2 through 5 in tabular form.

CONCLUSIONS

For the reasons stated above, it appears that, at least using present state-of-the-art techniques, measurements as to induced body currents at any particular location are likely to be unrepeatable and therefore not reliable. Nevertheless, in making the above-described

² Interestingly, as shown in Figures 3 and 4 of Appendix A, the ratio of maximum permitted induced current to maximum permitted E field exposure is nearly identical for controlled and uncontrolled environments at VHF frequencies.

measurements, I believe I was able to obtain some useful data as to the relationship between body currents and E fields. Thus, notwithstanding questions as to the accuracy of individual measurements, the overall trend of the data permits us to draw preliminary conclusions.

As shown in Appendix A, Figures 1 through 4, when the body is isolated from ground by simply wearing shoes and socks, the measured levels of induced current are always well below the maximum permitted levels for both the controlled and uncontrolled environments as specified in the 1992 ANSI/IEEE standard. Even when shoeless, the measured levels of induced current at VHF frequencies were also below the uncontrolled and controlled levels. At AM frequencies, the measurements are normally below the standard for controlled environments and typically only exceed the uncontrolled standard under the worst case condition of standing with one's arms over one's head.

There were, however, two instances -- one in front of the KCBS phasor and the other at Mt. Beacon -- where the measured induced currents divided by the field strength were considerably higher than other readings by a factor of between 2 and 10. This was true even though although the E fields at both locations where the measurements were made were well within the MPE. The KCBS anomalous reading exceeded the standard for one foot current; the Mt. Beacon readings exceeded the standard for both one foot and two

foot currents. I have no explanation for these anomalous results.

With the exception of these two anomalous points, each of the numerous measurements I took indicated that body currents in excess of the ANSI/IEEE limits would not be induced in E fields complying with the relevant MPE in real world conditions. Because of the consistency of this result, I believe there is a likelihood that further investigation may establish the foregoing hypothesis, or at least that body currents in excess of the ANSI/IEEE limits will be induced only at significantly greater percentages of the MPE than the existing literature would suggest.

These data must, of course, be treated with caution given the problems of meter reading and measurement techniques which I experienced. However, it nonetheless suggests that, under actual field conditions, RF fields within the MPE limits will not create induced body currents in excess of the ANSI/IEEE limits.

Clearly, more work will be necessary to establish meter reliability, develop consistent measurement procedures, and to determine whether additional measurements will be consistent with the above results. If the data gathered in CBS's preliminary measurements proves to be consistent with further measurements, it may be possible to conclude that compliance with the induced current standard will be achieved whenever the electric field exposure standards are satisfied. At the least,

CBS's preliminary measurements suggests that body currents in excess of the ANSI standard may be induced only at much higher percentages of the MPE standard than indicated by existing data.

* * *

I declare under penalty of perjury under the laws of the United States of America that the foregoing, and the attached Appendicies, is true and correct.



ALAN W. PARNAU

Executed on January 24, 1994

A

APPENDIX A

SUMMARY DATA RESULTS

Table 1

MEASUREMENT LOCATIONS

1. High Island

Location: Long Island, New York.

Broadcast Facilities on Site: WCBS (AM) and WFAN (AM)

Type of Meter: Narda Prototype

Date of Measurement: November 12, 1993

Measurement Locations:

- a. Inside tower fence (Measured E field = 599 V/m)
- b. 15 feet from tower fence (Measured E field = 365 V/m)
- c. Inside WCBS-WFAN doghouse (Measured E field = 1423 V/m)
- d. In front of WCBS-AM main transmitter (Measured E field = 56 V/m)

2. KCBS (AM) Site

Locations: Novato, California

Broadcast Facilities on Site: KCBS (AM)

Type of Meter: Narda Prototype

Date of Measurement: November 16, 1993

Measurement Locations:

- a. Base of KCBS (AM) tower #3 (Measured E field = 366 V/m)
- b. Inside Tower #3 doghouse (Measured E field = 808 V/m)
- c. In front of KCBS Phasor (Measured E field = 115.3 V/m)

3. KNX (AM)

Locations: Torrance, CA

Broadcast Facilities on Site: KNX (AM)

Type of Meter: Narda Production

Date of Measurement: January 6, 1994

Measurement Locations:

- a. Base of KNX (AM) main tower (Measured E field = 1406 V/m)
- b. 20 feet north of KNX main tower fence (Measured E field = 180 V/m)
- c. Base of KNX (AM) auxiliary tower, with main tower on (Measured E field = 171 V/m)

4. KRLA (AM) Site

Locations: Irwindale, CA
Broadcast Facilities on Site: KRLA (AM)
Type of Meter: Narda Production
Date of Measurement: January 7, 1994

Measurement Locations:

- a. Base of tower #5 (Measured E field = 1732 V/m)

5. Mt. Beacon - 4 FM stations

Location: Mt. Beacon, San Francisco
Broadcast Facilities on Site: 4 FM stations
Type of Meter: Narda Prototype
Date of Measurement: November 17, 1993

Measurement Locations:

- a. Between RFR signs (Measured E field = 49 V/m)
- b. Near auxiliary tower (Measured E field = 40 V/m)

6. Mt. San Bruno - FM-TV

Location: Mt. San Bruno, San Francisco
Broadcast Facilities on Site: FM-TV
Type of Meter: Narda Prototype
Date of Measurement: November 17, 1993

Measurement Locations:

- a. Near tower #2 (Measured E field = 19.8 V/m)
- b. Near CH #5 weather radar (Measured E field = 19.4 V/m)

7. Mt. Wilson - FM-TV

Location: Mt. Wilson, Los Angeles
Broadcast Facilities on Site: FM-TV
Type of Meter: Narda Production
Date of Measurement: January 7, 1994

Measurement Locations:

- a. Near first FM tower (Measured E field = 50 V/m)
- b. 30 feet from fence of First FM tower (Measured E field = 36.9 V/m)
- c. Near KTWV fence (Measured E field = 16.8 V/m)